Outlines

- Review of TOTEM’s Upgrade & Consolidation program
- TOTEM Readiness for Run Two
- Timing Detector Development
- Test-beams Timeline and Milestones
- Update on CT-PPS
- Publications & Analysis Highlights
Review of TOTEM’s Upgrade & Consolidation program

**Upgraded Roman Pot System**

**Consolidation**: Relocate pots at 214m and 203m to improve lever arm and tracking

**Upgrade**: Installation of cylindrical pots to house future timing detectors and legacy Horizontal Pots with RF shields for CT-PPS

March 4, 2015 LHCC Open Session
Roman Pot Readiness for Run Two

Full RP infrastructure deployed in LHC’s sectors 45&56 – **26 RPs installed!**

- **Oct 2014**
  - Service lines connected
  - Detector packages installed

- **Nov 2014**
  - Commissioning done
    - Sec. Vacuum & Cooling
    - Powering
    - Control loop
    - RP readout with DAQ
    - Interlock test - started
    - RP movement test from CCC - started

- **Jan-Feb 2015**
  - RPs are on schedule expected to run with the earliest LHC’s beam

- **Mar 2015**

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March 4, 2015
T1 Readiness for Run Two

- Maintenance activity is over

Sep 2014

- Tested on surface:
  - Low voltage
  - HV and gas
  - Control Loop
  - DAQ

Nov 2014

T1 is on schedule, ready to be installed into the CMS end-caps

March 2015
T2 Readiness for Run Two

- Up to the 11th of Feb T2 was fully checked and functional
- On the 12th due to mechanical stress one quarter was damaged. Due to the tight schedule, to avoid instabilities of the full arm it was decided to exclude the damaged quarter from the control loop
- Impact of having one T2 quarter not operational is less or equal of 1% in all the main Physics channels
**DAQ Consolidation**

- Replacement of the VME back-end with Ethernet 1Gb links, using RD51 Front-End Concentrator (FEC) cards
- Full compatibility with CMS DAQ and LHC TTC
- Procurement completed
- Commissioning done in the test-bench with real beam reading out the RPs
- 20kHz trigger rate measured: ~20x w.r.t. previous DAQ system
- Ready for installation in IP5

*More details at poster session: Upgrade of the TOTEM DAQ for the LHC’s Run Two*
DAQ Future Plans

- Scaling of the full infrastructure of TOTEM stand-alone DAQ
  - Storage space
  - Add computing resources CPUs, FPGAs
- Studies of on-line hardware algorithms:
  - Data-reduction
  - Filtration based on on-line reconstruction
- Further improvements of the DAQ rate capabilities
- Integration with the CMS DAQ
Timing Detector Development for Vertical Roman Pots

Objective:
- 4 timing detectors per arm in vertical RPs
- Detector installation foreseen by Sep 2015
- 50 ps resolution per arm (100 ps per detector)

Development:
- Intense test beam activity to characterise different detector and front-end configurations (Jul 2014 – Feb 2015).
- Optimization of connection capacitance, front-end amplifier configuration
  - Improve the S/N ratio
  - Improve the rise time
  - Improve the time resolution
Test-beams Timeline and Milestones

At PS pions 10GeV
- $\sigma(t)=300$ ps
- CIVIDEC Amplifiers
- CIVIDEC SC Diamond

At SPS pions 180GeV
- $\sigma(t)=\sim90$ ps
- GSI diamond sensor and associated hybrid with embedded front-end amplifier.

At SPS pions 180GeV
- $\sigma(t)=200-250$ ps
- Reduced capacitance on the sensor’s PCB
- TOTEM custom amplifiers

At DESY
- Requested test-beams for final design validation

First timing detectors are expected

At DESY – electrons 4 - 5.6GeV
- $\sigma(t)=95$ ps
- Test of TOTEM hybrids, optimizations towards final design

At DESY
- Requested test-beams for final design validation

Oct 2014

Dec 2015

Feb 2015

Sep 2015

Oct 2014

Nov 2014

March 4, 2015

LHCC Open Session
Test-beam at DESY

“DATURA” tracker 18μm pitch pixel

GSI hybrid HADES Coll.

TOTEM hybrid 4 pixel diamond with final geometry for Vertical RP
TOTEM Hybrid

Pixel metallization from GSI:
- Hybrid1 - 1 pixel with C ~2pF (largest pixel foreseen in TOTEM)
- Hybrid2 - 4 pixel with C ~0.2pF to ~0.6pF

Amplifier by TOTEM based on GSI design

We can test the final pixel geometry foreseen in TOTEM
Time Resolution

Time difference measured between Det1 ($C = 2\,\text{pF}$) and Det2 ($C = 0.29\,\text{pF}$)

Time resolution:
\[ = \frac{\sigma_{\Delta T}}{\sqrt{2}} \]
\[ = 95 \, \text{ps} \]
• Diamond bulk efficiency calculated for the first time: >98%
• More exercises and a better set-up are needed to measure the overall efficiency taking into account pixel geometry (dead zone between pixels)
Update on CT-PPS: Components installed in tunnel

TCL 4 & TCL 6 in 4-5 and 5-6

Electrical patch panel
Service lines for LV/HV/DAQ

CT-PPS specific:
• 2 * RP box with RF shield in 4/5
• 2 * RP box with RF shield in 5/6
• 1 * RP cylinder in 4/5
• 1 * RP cylinder in 5/6

J.Varela, CT-PPS Status Report - March 3, 2015
Update on CT-PPS: Summary

- Roman Pots are installed & calibrated in the LHC tunnel at ip5
- Collimators TCL4 and TCL6 are installed
- RP Si-strip detectors & electronics successfully tested
- Insertion of horizontal RPs at low $\beta^*$ under discussion with LHC coordination
- Quartic fabrication and integration in cylindrical Roman Pot under preparation
- Quartic electronics and firmware is under design
- 3D pixel sensors production is in preparation at CNM
- CT-PPS is joining Tracker production of DAQ boards (uTCA)
- Beam tests scheduled at Fermilab & CERN SPS
- Active R&D is several fronts
- Installation of new components in tunnel (FE electronics/clock/DAQ) needs to be specified and summarized in addendum to ECR upgrade
Publications (updates since last LHCC)

Selected highlights of 2014 in New. J. Phys.:
- “LHC optics determination with proton tracks measured in the Roman Pots detectors of the TOTEM experiment”, New J. Phys. 16 045018

Accepted for publication:

To be submitted (editorial process being finalized):
- “Evidence for non-exponential elastic proton-proton differential cross-section at low $|t|$ and $\sqrt{s} = 8$ TeV by TOTEM”

In preparation:
- paper on Coulomb-hadronic interference in elastic scattering at $\sqrt{s} = 8$ TeV
- note on low mass resonances in DPE (together with CMS)
Forward charged particle pseudorapidity density using a displaced interaction point

-7 < \eta < -6

3.7 < \eta < 4.8

11.25 m

Inclusive pp, \( \sqrt{s} = 8 \) TeV

- TOTEM: \( N_{ch} \geq 1 \) in \( 3.7 < \eta < 4.8 \) or \(-7.0 < \eta < -6.0\)
- CMS-TOTEM: \( N_{ch} \geq 1 \) in \( 5.3 < \eta < 6.5 \) or \(-6.5 < \eta < -5.3\)

measurement with bin-to-bin uncertainty

total uncertainty

not possible to make reliable measurement in \(-6.9 < \eta < -6\) due to large material amount
Evidence for non-exponential elastic proton-proton differential cross-section at low $|t|$ and $\sqrt{s} = 8$ TeV

$$\frac{d\sigma}{dt} \propto |F_{C+H}^2| = \text{Coulomb + hadronic + “interference”}$$

from constrained by measured $e^{-B(t)}$

QED

$$B(t) = b_1 t + b_2 t^2 + \ldots$$

$N_b = \# \text{ parameters in exp.}$

Simplified West-Yennie (SWY) [1]: often used “standard”, only compatible with pure exponential amplitude & constant phase


Exclude Coulomb-hadronic interference with constant phase & constant exponential slope for hadronic amplitude ($N_b = 1$) at $>7\sigma$ using same data $\Rightarrow$ ruling out SWY approach
Conclusions

- Commissioning of the Roman Pots movement and interlock system ongoing
- T2 is installed, three quarters are operational, one will be repaired
- T1 is being installed
- Timing detector for Vertical RPs is close to final design
- The full TOTEM Apparatus commissioning is progressing smoothly and expected to be ready to exploit the earliest LHC’s beams:
  - LHCf and/or VdM fills in May 2015
  - TOTEM special Physics run in Sep 2015
- CT-PPS: Qualify new horizontal pots with cylindrical shape and pots with RF shields by means of insertion exercises
Thank you